SPATIAL VISUALIZATION ABILITY AMONG ENGINEERING STUDENTS IN MALAYSIA

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ABSTRACT

A spatial visualization ability is very important in engineering field and it is positively correlated with achievement in engineering disciplines. Therefore, this research was carried out to identify the spatial visualization ability by engineering students in Malaysia. Given that first-year engineering students enter the academic field of engineering with a variety of backgrounds and experiences, and thus, varying degrees of spatial visualization ability development. It required for additional attention and effort in some students to get a better result in their study. Sometimes standard instruction and coursework at the introductory level of engineering graphics is not enough. Students on this lower end of visualization skill development need to close the gap between the level of their skills in this area and the level skills of their peers (Piburn et al, 2002; Fennema & Sherman, 1977). Since spatial visualization ability skills are essential for success in engineering and other technical fields of study, it is important to develop visualization ability during the developmental years of students. Therefore, this research will lead us to achieve the following research objective, to access the engineering students' spatial visualization ability in Malaysia according to year of study and according to gender. This research is using descriptive statistics to find the central tendency especially mean value, frequency and percentage of the data. The finding spatial visualization ability of engineering student at in Malaysia is to be at moderately high. This is based on the achievement of the proficiency testing of each aspect of visualization test involved in this study. Thus, suitable teaching approach should be taking into consideration in order to provide the right technique to enhance students' spatial visualization ability.

Keywords: spatial visualization ability, engineering students

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1.0 INTRODUCTION

Spatial visualization ability is a way of thinking in which images produced in the recall of the memory (Ahmad Rizal, 2009; Sorby, 2007). In developing the knowledge, the students use their mental schema to visualize or develop a particular pictures or images. Usually, students face a problem when ascertaining the subject matter in engineering drawing where it needs the high level of visualization skills (National Science Foundation, 2006). There are many researches done in the areas of science, medicine, mathematics, and technologies (Abe and Yoshida, 1999; Adanez and Velasco, 2004; Alias et al., 2002; Basham, 2007; Contero et al., 2005). For example, in construction technology course, students need to visualize the construction process, materials and components. Besides that, in computer technology field, visualization skill is one of the recognized fields that study the interaction between computer and human in creating graphic illustrations of information efficiently. Students must understand the basic concepts of engineering drawing in order to assist them in understanding the complexity of learning in other engineering subjects. However, to master engineering drawing basic concepts, students must first master spatial visualization ability. Some studies show that students usually face difficulty in solving problems in engineering drawing because of poor spatial visualization ability. Contero et al. (2005) suggested that engineering students need to improve their visualization skills because it is necessary in explaining concepts, ideas and processes as well as to attract attention and information delivery.

2.0 LITERATURE REVIEW

The problem that exists as in today whereby the lecturers face difficulties to develop student's understanding of the dynamic learning content by using static media such as sketches on the blackboard or through printed modules (Ashwin, 2004; Bullough, 1988). Sketching and drawing are two of the most often activities for improving the spatial visualization ability. The conventional teaching approach in the learning process causes the student to face difficulties to memorize and understand back what they have failed to do so in the classroom. When the students do a self-study, their cognitive level will increase. Thus, the heavy load of information in the working memory will cause the failure of information to be registered in the long term memory during the conduct of that activity (Tabbers et al., 2004; Chandler, 1998; Klein, 1996). Edgar Dale found in 1969 that, after learning new information in two weeks, students can remember only 29% of what they have read and heard. On the other hand, students can remember up to 90% of what they say and do. Generally, Dale found that, when learning activities are

conducted actively, the material will store longer in memory. Besides that, Kolb (1984) also found that, in learning activities, experience is one of the most powerful elements. Unfortunately, there are not many experiences provided to the students. This is because of safety, economic factor, and others.

Raudebaugh (1985) agrees that spatial visualization ability are the most important element in engineering drawing where it is difficult to teach by using the traditional method. By using the traditional method, students may master the knowledge of graphic language such as symbol, standardization, and other principles which is related to engineering drawing. However, it does not mean that those students are excellent in the spatial visualization ability. Spatial visualization ability is not only the ability to create and manipulate the image but also requires to present the image verbally or in graphically. Moreover, Tversky (1972) has found that information of verbal and visual are encoded differently depending on the student's perception of information application. Besides that, Contero et al., (2005) suggested that engineering students need to consistently improve their skills as spatial visualization ability plays a significant role in education as an explanation, tool, and information. It is also used to explain its concepts, its ideas and its processes, and used to stimulate interest and provide information. There are many other visual functions such as improving the performance of memory, causing emotional response, enriching the reading and as a demonstration. This statement is supported by a study from the Ramanujan Dimension Group (2001) which stated that the use of visuals can be applied to convey different information in education. Not only that, television program provides a visual which can be used by teachers to achieve these functions.

The research in method of increasing student's visual abilities in teaching and learning should be carried out. There are lots or research has been done in the most areas in science and technologies especially in engineering (Basham, 2007; Contero et. al., 2005; Sorby et. al., 2005; Sorby, 2007). As examples in chemical engineering, intuitive understanding may be developed when student observe visual interactions among numerous atoms, and subject those simulated atoms to fundamental laws of nature such as conservation of energy, gravitational and electrostatic forces. Besides that when learning construction technology, students need to visualize material and sequences of the construction process also component of the facility are assembled. In computer science, interactive visualization has become a recognized branch of knowledge that studies how human-computer interactions create graphic illustrations of information efficiently. In short, each discipline in engineering and computer-related field lends itself to incorporating interactive simulations in teaching and learning. In investigating effective and engaging ways to teach engineering course such as engineering drawing, the best practice offer way to optimize their use through co-constructed meaning and application (Nguyen & Khoo, 2009).

Nowadays, students are more discerning and exposed to advanced technological developments. They are also being exposed to the emergence of new inventions that they never imagined before. Spatial ability is the ability that can be difficult for some people even with a sound background knowledge in engineering. So a career in engineering should also develop in line with developments in technology and knowledge society and engineering graduates should be exposed to high visualization skills to face these challenges. The curriculum development, especially in the early years of the degree program, needs to overcome the lack of imagination and visualization skills apparent in the students.

3.0 RESEARCH DESIGN

In this research, this study was conducted on 1253 undergraduate students in which they were randomly selected by each faculty in Malaysia University. In order to identify the students' level of spatial visualization ability, this study applied three standard visualization tests on the visualization skills and their components. This study was carried out quantitatively using descriptive and inferential statistics. The data were analysed using Statistical Packages for Social Science (SPSS) version 13.0. The descriptive statistics provides mean value, frequency and percentages. According to Yahya et al. (2005), the use of descriptive analysis is to explain or provide an overview of the information or data obtain from the population or sample. Meanwhile, inference analysis is used to describe the relationship between achievement tests and gender differences of engineering students. The inference statistics used in this study is to test correlation at 0.05 alpha level and one way ANOVA analysis. The instrument used for this study was adopted from the Spatial Visualization Ability Test (SVAT), Mental Rotation Test (MRT), and Differential Aptitude Test: Space Relations (DAT: SR). The tests used are standard achievement tests. Thus, the reliability and validity of the test have been determined in order to ensure that the instrument is consistent and credible. Meanwhile, the content validity of instruments is determined through a verification process carried out by the expertise in this discipline of study. Items are reviewed in terms of content, namely the relationship between the research questions and the scope of the study.

Table 1 Alpha Value for Research Instrument

Research Instrument	**Alpha value**
SVAT	0.804
MRT	0.803
DAT: SR	0.805

4.0 RESULTS AND DISCUSSION

Spatial Visualization Ability by Year of Study

Table 2 shows the scores on visualization test based on year of study. The findings showed spatial visualization ability of engineering students in Malaysia are at moderately high level. This is based on the achievement of the proficiency tests of each aspect of visualization test involved in this study. Meanwhile, based on the students' academic year, the analysis found that fourth year students' have high level of spatial visualization ability. On the other hand, spatial visualization ability of the third year, second year and first year students are at moderately high.

Table 2 Average score of visualization skills test by year of study

Year of Study	Average Score of Visualization Skills Test (%)		
	DATSR	SVAT	MRT
1	72.2	69.2	54.8
2	74.3	73.3	58.7
3	82.2	82.8	69.0
4	85.4	83.6	71.3
Average Score (%)	**78.2**	**77.1**	**63.2**

These results are paralleled with a study that was conducted by Nordin and Saud (2007), which related to the visualization ability of engineering high school students. The results showed that on the average, students studying engineering in this study only had a satisfactory level of mastery in one of the six visualization tests. The analysis of this study has proven that more than half of the students are at the moderate level and are lacking in the aspect of mentally transforming, developing, folding and rotating object mentally using visualization skills. Besides that, studies conducted by Dayana (2013) and Rebecca (2000) showed that students with higher levels of visualization ability might be influenced by students' previous experience especially during their earlier exposure in subjects such as geometry or engineering drawings. In addition, according to a study done by Oyanka and Kinsey (2007), various engineering disciplines apply spatial visualization ability in teaching and learning, such as CAD software in order to enhance the visualization skills of the students.

Spatial visualization ability are one of the aspects of intelligence found in all humans. The difference is the level of visualization capabilities; they have either be high or low. According to Alias (2002) and Nordin (2009), visualization ability is important for learning and solving engineering problems. With high visualization ability, students in engineering are able to solve and understand an abstract concept that is difficult to be understood by other students (Sorby, 2009). Therefore, Malaysia's educational goals to produce technical human resource with good knowledge in problem solving and effective in technical fields will not be achieved if the level of visualization skills is at moderately high level. Poor visualization skills will lead the students to have difficulty in problem solving activities such as in doing product design, in understanding drawings or thinking of other engineering solutions.

Spatial Visualization Ability according to Gender

Table 3 shows the average test scores of spatial visualization ability across gender.

Table 3 Average score of visualization skills test according to gender

Gender	**Visualization Skills Test (%)**		
	DAT: SR	**SVAT**	**MRT**

Male	78.8	77.1	64.1
Female	77.7	77.1	62.4

There is a great deal of prove to show that the spatial skills of female lag significantly behind those of their male counterparts. Theories for the cause of these differences include the assertions that spatial ability related to a male sex hormone (Hier & Crowley, 1982) or that environmental factor is the main reasons for male-female differences in spatial skill levels (Fennema & Sherman, 1977). Furthermore, the factors influenced spatial ability developments occur in a few psychology studies such as sex, age and experience (Miller, 1996). Besides that, Vandenberg and Kuse (1978) found that male showed greater ability than females in spatial mental rotation task.

Two studies were published in memory and cognition to determine the gender gap through Mental Rotation Test achievement (MRT). Based on this test, students asked to look at an object of 3-dimension. Then, they are given four answers (two rotation is the original object) to identify two appropriate alternative with the original object. These studies use the ratio of performance to conclude that gender differences for mental rotation skills are significantly reduced when the effect of performance factors such as length of time and strategy to guess the answers eliminated. The first study focused only on the MRT, while the second study provides an analysis of fifteen skills assessment and the study area, proved that there are gender differences only in tasks that require mental rotation. In addition, several studies in spatial abilities conducted and the researcher found that there are differences between the gender differences where the male students who enter the technology field have higher spatial ability compared to male students in Social Sciences while the female students in the technology field has the spatial ability higher than female students in Social science but lower than male students in the Social Sciences (Nordvik, 1998). However, Feingold (1993) and McGee (1979) found that there is no significant difference in the spatial ability between male and female students.

Levine et. al. (1999) state that average male exceed woman in spatial ability in the fourth stage. This is because males tend to look for a technique or method by using space and direction or orientation strategy while females prefer to use sign and route directions (Lawton, 1994; Geary, 1998). This study is consistent with the findings Koenig (1999) found that women's advantage is in relation to absolute space (location of the object) while the male advantage is in the space coordinating relations (distance and direction). The holistic strategy has found to be most effective (i.e. less time consuming) in timed tests. Linn & Peterson (1985) therefore, concluded that “spatial strategy selection” is a factor in gender

differences in mental rotation tasks. However, Hsi et. al. (1997) determined that spatial strategies can be acquired through training.

5.0 CONCLUSION AND SUGGESTIONS

Improving the students' spatial visualization ability is now becoming the main topic of interest to educators and researchers in the disciplines of engineering and related industries. For the industry to remain competitive in the global market, students graduating from the engineering program should have strong visualization skills to communicate effectively and grow professionally in the engineering field. Therefore, engineering students should be provided with the knowledge and basic skills of drawings in various disciplines or fields of engineering. Most studies in spatial visualization ability investigate and test new methods of improving the skills such as conventional, computer-based and the integration methods. Some of the alternatives to traditional methods have been successfully adopted, while others are still being tested for their effectiveness on students, especially in engineering. Thus, there is a need for comprehensive research on improving learning and teaching of spatial visualization ability to students in engineering programs or courses. In conclusion, this study showed that there are some elements of spatial visualization ability are still not dominated by handful of engineering students at Research University. More attention should be given to the development of these visualization spatial skills in all engineering programs offered at this campus. Appropriate approach for teaching is needed to help engineering student in enhancing their spatial visualization ability. Thus, various parties must help the students to improve their spatial visualization ability with the effective teaching and learning environment. The overview of this study will help the Ministry of Education, researchers, educators and students on the impact of new teaching methods in teaching engineering drawing for the spatial visualization ability for engineering students in Malaysia.

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